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Testing Truck-Mounted Vacuum and Air Conveyor Systems for Oil Spill Recovery

Mason and Hanger-Silas Mason Co., Inc.
Leonardo, NJ

Prepared for

Municipal Environmental Research Lab.
Cincinnati, OH

Oct 82

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National Technical Information Service
NTIS

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October 1982

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TESTING TRUCK-MOUNTED VACUUM AND AIR CONVEYOR SYSTEMS FOR OIL SPILL RECOVERY

by

Donald C. Gates and Kevin M. Corradino
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Contract No. 68-03-3056

Project Officer

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MUNICIPAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

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16. ABSTRACT

Two different vacuum truck designs were evaluated for oil recovery performance at the U.S. Environmental Protection Agency's Oil and Hazardous Materials Simulated Environmental Test Tank (OHMSETT) facility in September 1980. These were a Vactor Model 2045 air conveyor design made by the Meyers-Sherman Company and a standard vacuum truck made by Coleman Environmental and Pollution Control Equipment Co., Inc. Changes in recovery efficiency and oil recovery rate were found while varying oil slick thickness, oil viscosity, hose length, and air pump speed for the trucks. The air conveyor was additionally tested using different suction hose heights above the slick.

The air conveyor tests resulted in an average oil recovery rate of 4.4 m^3/hr and a 61% oil recovery efficiency. Efficient recovery of thin oil slicks appears to be an advantage of air conveyors. Tests of the standard design vacuum truck produced an average oil recovery rate of 2.4 m^3/hr and an 18% oil recovery efficiency. Standard vacuum trucks seem particularly suited to recovery of thick slicks. The addition of skimmer attachments in lieu of a simple hose intake, was evaluated during this test program and was found to increase recovery efficiency without affecting oil recovery rate.

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FOREWORD

The U.S. Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimonies to the deterioration of our natural environment. The complexity of that environment and the interplay of its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution; it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems to prevent, treat, and manage wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, to preserve and treat public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research and provides a most vital communiations link between the research and the user community.

This report describes the testing of truck-mounted vacuum and air conveyor systems for recovering spilled oil. Based on results presented here, more efficient operating techniques can be developed for use of these trucks at oil spills. The methods, results, and techniques described are of interest to those responsible for specifying, using or testing oil spill cleanup equipment. Further information may be obtained through the Solid and Hazardous Waste Research Division, Oil and Hazardous Materials Spills Branch, Edison, New Jersey.

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The air conveyor tests resulted in an average oil recovery rate of 4.4 m^3/hr and a 61% oil recovery efficiency. Efficient recovery of thin oil slicks appears to be an advantage of air conveyors. Tests of the standard design vacuum truck produced an average oil recovery rate of 2.4 m^3/hr and an 18% oil recovery efficiency. Standard vacuum trucks seem particularly suited to recovery of thick slicks. The addition of skimmer attachments, in lieu of a simple hose intake, was evaluated during this test program and was found to increase recovery efficiency without affecting oil recovery rate.

This report was submitted under Job Order No. 80 in partial fulfillment of Contract No. 68-03-3056, by Mason & Hanger-Silas Mason Co. Inc. with the sponsorship of the U.S. Environmental Protection Agency. This report covers the period of September 19, 1980 through September 26, 1980. Work on this report was completed June 4, 1982.

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LIST OF CONVERSIONS

METRIC TO ENGLISH

To convert from	to	Multiply by
Celsius	degree Fahrenheit	$t_C = (t_F - 32)/1.8$
joule	erg	1.000 E+07
joule	foot-pound-force	7.374 E-01
kilogram	pound-mass (lbm avoir)	2.205 E+00
meter	foot	3.281 E+00
$meter_2$	$inch_2$	3.937 E+01
$meter^2$	$foot^2$	1.076 E+01
$meter^2$	$inch^2$	1.549 E+03
$meter^3$	gallon (U.S. liquid)	2.642 E+02
$meter^3$	liter	1.000 E+03
meter/second	foot/minute	1.969 E+02
meter/second	knot	1.944 E+00
$meter^2$/second	centistoke	1.000 E+06
$meter^3$/second	$foot^3$/minute	2.119 E+03
$meter^3$/second	gallon (U.S. liquid)/minute	1.587 E+04
newton	pound-force (lbf avoir)	2.248 E-01
watt	horsepower (550 ft lbf/s)	1.341 E-03

ENGLISH TO METRIC

centistoke	$meter^2$/second	1.000 E-06
degree Fahrenheit	Celsius	$t_C = (t_F - 32)/1.8$
erg	joule	1.000 E-07
$foot_2$	$meter_2$	3.048 E-01
$foot^2$	$meter^2$	9.290 E-02
foot/minute	meter/second	5.080 E-03
$foot^3$/minute	$meter^3$/second	4.719 E-04
foot-pound-force	joule	1.356 E+00
gallon (U.S. liquid)	$meter_3$	3.785 E-03
gallon (U.S. liquid)/minute	$meter^3$/second	6.309 E-05
horsepower (550 ft lbf/s)	watt	7.457 E+02
$inch_2$	$meter_2$	2.540 E-02
$inch^2$	$meter^2$	6.452 E-04
knot (international)	meter/second	5.144 E-01
liter	$meter^3$	1.000 E-03
pound force (lbf avoir)	newton	4.448 E+00
pound-mass (lbm avoir)	kilogram	4.535 E-01
$pound/foot^2$	pascal	4.788 E+01

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SECTION 1

INTRODUCTION

Vacuum systems are one of the most commonly used pieces of equipment at oil spills. They are mobile, simple to operate, and generally complete skimming systems. Two types of vacuum systems are available: air conveyors and vacuum trucks. Air conveyors are more costly than vacuum trucks. Air conveyors use a large diameter hose (typically greater than 15 cm) and a high flowrate of air to convey material into a collection tank (Figure 1). Air conveyors require that the suction hose inlet remain above the material being picked up so an adequate air flow can be maintained. Vacuum trucks use smaller diameter hose (typically 7.6 cm) and a low volume blower to evacuate a truck-mounted collection tank (Figure 2). The hose inlet must be placed in or on top of the material being recovered because the air flow in the hose is not sufficient to air-convey material up the hose. The owners have suggested that vacuum trucks may also be efficient in transferring recovered oil from primary recovery devices to final storage/reclamation sites.

These two systems were tested at the U.S Environmental Protection Agency's Oil and Hazardous Materials Simulated Environmental Test Tank (see Appendix A) during the period 19-26 September 1980. A Vactor Model 2045 air conveyor truck manufactured by Meyers-Sherman Company, Streator, Illinois and operated by the owner, Axxon Industrial Corporation, Iselin, New Jersey was evaluated. Olsen & Hassold, Inc. of Paterson, New Jersey supplied a vacuum truck made by Coleman Environmental & Pollution Control Equipment Co., Inc., East Patchogue, New York.

Twenty-four calm water tests and one harbor chop test were planned during a 5½-day period--13 air conveyor tests and 11 vacuum truck tests (Table 1). System performance was evaluated using recovery efficiency and oil recovery rate. Recovery efficiency, RE, is defined as the oil volume recovered divided by the oil and water volume recovered, multiplied by 100. Oil recovery rate, ORR, is the oil volume recovered divided by the recovery time. Changes in RE and ORR were measured with varying slick thickness, oil viscosity, hose length, and blower speed for both air conveyor and vacuum trucks. Air conveyors were also evaluated for various hose heights above the oil slick.

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TABLE 1. TEST MATRIX

Test no.	Oil type (L,H)	System type (A,V)	Slick thickness (mm)	Wave condition	Blower speed (rpm)	Hose length (m)	Hose diameter (cm)
1	L	A	2	calm	1100	7.6	20.3
2	L	A	12	calm	1100	7.6	20.3
3	L	A	12	calm	1450	7.6	20.3
4	L	A	12	calm	1800	7.6	20.3
5	L	A	25	calm	1100	7.6	20.3
6	L	A	25	calm	1450	7.6	20.3
7	L	A	25	calm	1800	7.6	20.3
8	L	A	25	calm	1800	7.6	20.3
9*	L	A	25	0.3m HC	1800	7.6	20.3
10	L	A	25	calm	1800	14.3	20.3
11	H	A	12	calm	1800	7.6	20.3
12	H	A	25	calm	1100	7.6	20.3
13	H	A	25	calm	1450	7.6	20.3
14	H	A	25	calm	1800	7.6	20.3
15	L	V	2	calm	1200	6.1	7.6
16	L	V	12	calm	1200	6.1	7.6
17	L	V	25	calm	1200	6.1	7.6
18	L	V	25	calm	1200	6.1	7.6
19	L	V	25	calm	1200	32.0	7.6
20	H	V	12	calm	1500	6.1	7.6
21	H	V	12	calm	1500	61.0	7.6
22**	H	V	12	calm	2300	61.0	7.6
23**	H	V	25	calm	1500	61.0	7.6
24**	H	V	25	calm	1500	9.1	7.6
25	H	V	25	calm	1500	9.1	7.6

HC = Harbor chop wave condition
L = Light oil, low viscosity
H = Heavy oil, high viscosity
A = Air conveyor truck
V = Vacuum truck

Note: * Test 9 was not performed

** Test 22, 23, and 24 incorporated skimmer heads

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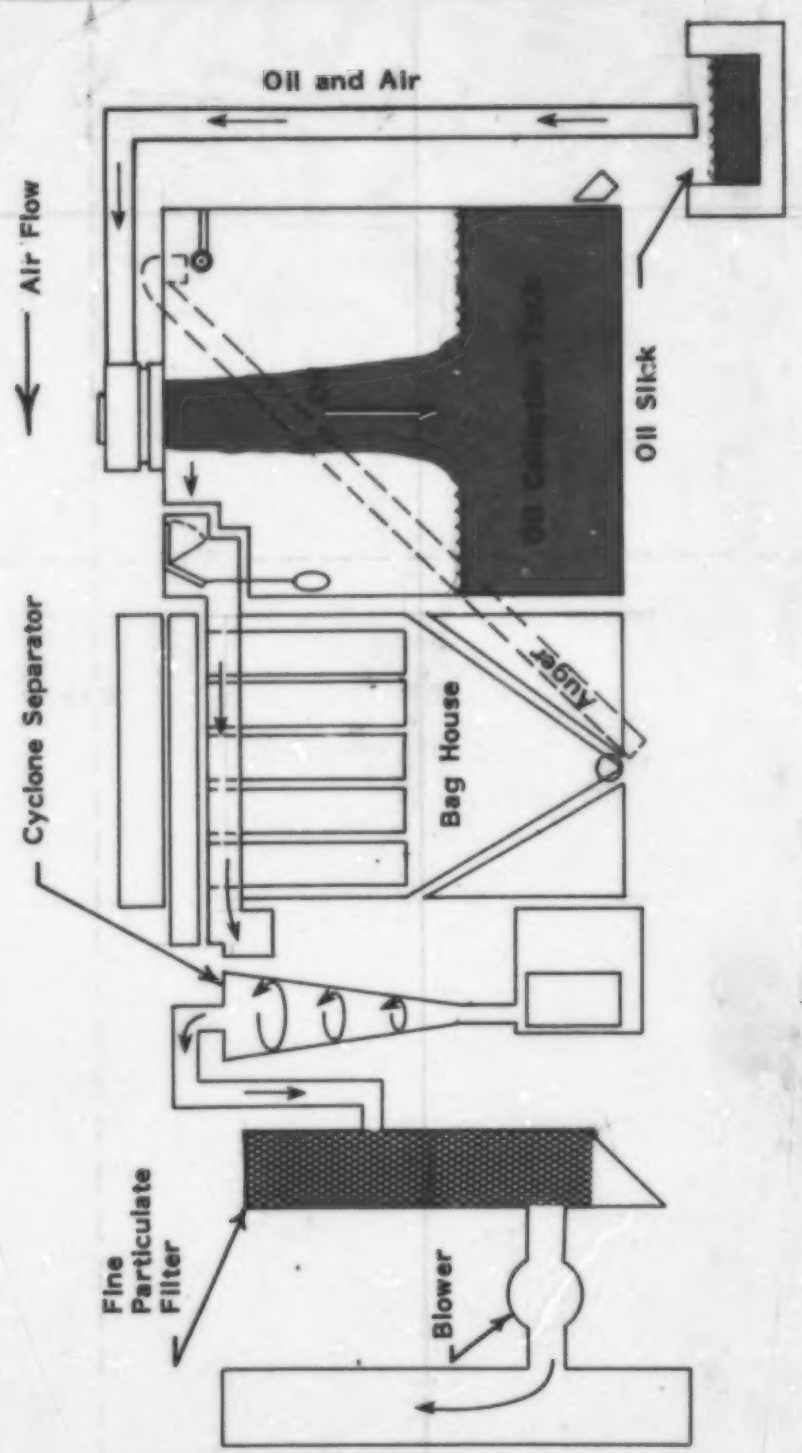

Figure 1. Air conveyor operation schematic

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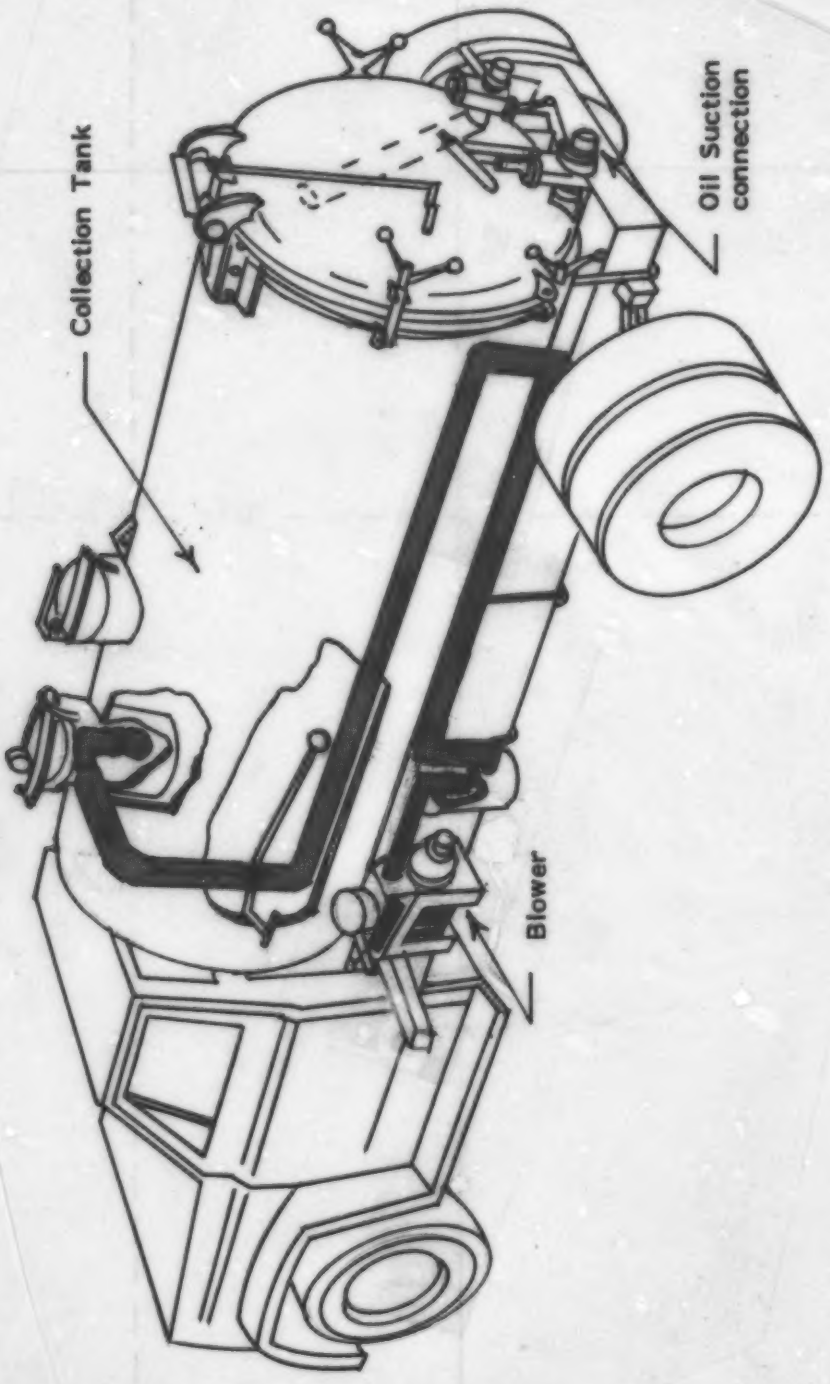

Figure 2. Vacuum truck illustration

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SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

The air conveyors recovered spilled oil at about twice the rate of the vacuum truck and with three times the efficiency. Use of air conveyors is especially recommended with thin spills or with highly viscous products. The vacuum truck appeared more suited to recovery at spills where thick slicks were present or for transporting recovered products from temporary storage at the spill to a final disposal site. Air conveyors are difficult to pump out unless a pit is available as they typically unload like a dump truck. Additional testing will be required to reconfirm the results obtained and to provide additional data to establish trends at a variety of conditions.

One must be careful before using the equipment to inspect it for holes in the tank or hoses and for contamination caused by residue from a previous cleanup. Difficulty can also be anticipated in deploying and handling long lengths of the large diameter hose used on air conveyors, although a wheel-mounted hose support system is of some help. Figure 3 shows handling of air conveyor hose; Figure 4 illustrates handling vacuum suction hose. Addition of a pipe tap in the tank bottom is suggested to aid in emptying an air conveyor truck.

Air Conveyor

Air conveyor results show an average recovery rate for all tests of 4.4 m^3/hr and an oil recovery efficiency of 61%. Adding hose sections will increase the recovery efficiency while decreasing the oil recovery rate. No significant performance changes were found due to viscosity changes. Low blower speeds produced the best recovery efficiency on thin slicks and high blower speeds worked best on thick slicks (Figure 5). Blower speed variations had little effect on ORR values. An increase in slick thickness increased ORR without affecting RE.

Addition of an outlet in the tanks of air conveyors to allow for removal of the free water and oil is recommended. The truck tested was only equipped with one valve for removing liquid above solids which had settled on the tank bottom. Addition of a float level indicator in the tank would aid operators in determining the amount of recovered fluid in the tank. Development and testing of skimming heads is needed to further increase the recovery efficiency of air conveyors. These heads will also be needed to recover oil slicks effectively in waves. This improvement was not tested during this program due to the incompatibility of the available skimmers with air conveyor hose.

Vacuum Truck

The average oil recovery rate for all vacuum truck tests was 2.4 m^3/hr with an 18% oil RE. Recovery efficiency increased with blower speed, but no significant

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changes were found for various hose lengths, oil viscosities, or slick thicknesses. Oil recovery rate was unaffected by blower speed or hose length. An increase in test oil viscosity slightly decreased ORR, while increasing the slick thickness increased ORR. Placing simple, weir-type skimmers at the end of the inlet hose doubled the RE without affecting ORR. Floating skimmers appeared to respond to waves better than a man holding the hose in the slick.

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Vacuum trucks seem particularly suited for use in thick slicks and with skimmers attached to the inlet for increased RE. Testing with additional skimmers is recommended to determine applicability and performance. Large amounts of water can be expected in the recovered fluid unless the slick is thick or the oil viscous.

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Figure 3. Air conveyor with 14.3-m hose length.

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Figure 4. Handling of vacuum truck suction hose.

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2mm SLICK, LIGHT OIL
12mm SLICK, LIGHT OIL
12mm SLICK, HEAVY OIL
25mm SLICK, LIGHT OIL
25mm SLICK, HEAVY OIL
31mm SLICK, HEAVY OIL
6-1/2"
9-1/8"
RECOVERY EFFICIENCY (%)
0 10 20 30 40 50 60 70 80 90 100 110 120
750 1100 1450 1800
BLOWER SPEED (rpm)

Figure 5 : AIR CONVEYOR RE VS. BLOWER SPEEDS ALL OILS AND SLICK THICKNESSES

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SECTION 3

TEST APPARATUS AND PROCEDURE

TEST APPARATUS

Vacuum Trucks

Each truck is equipped with a skimming hose, pump, and storage tank. Standard vacuum trucks use a low blower speed to evacuate a pressure vessel with a capacity of 1.1 to 20.8 m^3 (300 to 5500 gallons) to about 7.2 kPa (29" of water) vacuum. The open inlet hose end is placed in the oil slick and the valve opened to the evacuated pressure tank. Atmospheric pressure pushes the oil up the hose into the tank. The system will lose vacuum rapidly if the hose end draws air. Tank contents are emptied through the inlet by pressurizing the tank using the blower in reverse.

Air Conveyors

Air conveyors use high volume capacity blowers to create 2.5 kPa (10" of water) vacuum to pull air, liquid, or loose material (e.g. bricks) through a large 152 to 305 mm (6 to 12") diameter duct hose into an enclosed dump-type truck. The blower is protected from particulates and liquids by cyclonic separators and/or a baghouse on the truck. Typically, particles over 200 microns diameter are removed with the blower filter. Recovered material may be offloaded using a hinged rear door to dump the entire contents or liquids may be pumped out using a pipe tap, typically 127 mm (5"), in the rear door.

TEST PROCEDURES

Oil slicks of various thicknesses were pumped onto the surface of salt water in the tank in the area between the main and auxiliary bridge skimming booms (area approximately 354 m^2). A vacuum truck or an air conveyor truck was parked on the west deck of the tank. (See Figure 6.) The suction hose was then positioned to recover the oil slick while contending with various hose lengths, oil viscosities, blower speeds, and hose skimming heads. Men equipped with fire hoses were used to thicken the slicks as necessary. Oil recovery data was obtained after pumping the recovered fluid from the truck collection tank to the auxiliary bridge recovery tanks with an OHMSETT-supplied 3-inch Wilden double-diaphragm air-operated pump. The volume of recovered fluid was determined by measuring the height of fluid in each recovery tank with a dipstick. The water was then stripped off and the residual oil volume measured. Collected oil samples were taken with a stratified sample thief. The samples were then analyzed in the laboratory to determine oil and water recovery volumes for calculating recovery efficiency and oil recovery rate. Appendix B gives properties of test oils used and OHMSETT tank water. Still 35-mm photographs and 16-mm motion pictures were used to record the events.

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SECTION 4

RESULTS AND DISCUSSION

AIR CONVEYORS

Recovery efficiency for the air conveyor ranged from a low of 28% oil to a high of 86%. Average RE was 61%. Increasing the length of the hose on the air conveyor from 7.6 m to 14.3 m raised the RE to 72% (compare results of Tests 10 and 14 as shown in Table 4) but lowered the ORR to 5.2 m^3/hr. A large amount of fluid discharged from the 14.3-m long hose when the blower was shut off, indicating that some of the fluid recovered was held on the bottom of the slightly inclined intake pipe instead of being sucked up by the air flow. RE peaked when the intake hose was 9.5 cm above the water, as shown in Figure 7. The suction cone is illustrated in Figure 8. This is an important observation for future design of floating heads. Tests using low blower speeds gave best RE results for thin slicks (12 mm) while high blower speeds gave best RE results with the thicker slicks (25 mm). RE proved to be nearly independent of oil viscosity and slick thickness (Figure 9).

Results for oil recovery rate ranged from 0.4 to 7.8 m^3/hr. Average ORR was 4.4 m^3/hr. Oil recovery rate appears to be independent of hose-to-slick vertical separation, until a distance of 9.5 cm is reached, at which point it drops (Figure 10). Blower speed and oil viscosity showed no significant effects on ORR (Figure 10). The ORR increased as the slick thickness increased, see Figure 11. Table 2 displays results of 3 specific tests selected from the 14 performed. These three tests relate best and worst performance achieved at OHMSETT.

TABLE 2. BEST AND WORST PERFORMANCE - AIR CONVEYOR

	RE %	ORR m^3/hr	Hose height* cm	Hose length m	Slick thickness mm	Blower speed rpm
Best performance	85.4	7.8	9.5	7.6	25	1800
Worst RE	27.7	6.9	5.7	7.6	25	1100
Worst ORR	62	0.4	7.6	7.6	2	1100

*Represents distance of hose end above the water surface

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VACUUM TRUCK

The vacuum truck is shown operating in Figure 6. Recovery efficiency for vacuum trucks ranged from 5 to 40% oil with an average of 18%. Tests plotted in Figure 13 show that RE increased slightly as blower speed increased. No significant changes in RE were observed as a result of varying hose lengths. As the slick thickness was increased, the RE showed a greater increase with heavy oil than with light oil, as shown in Figure 14.

Oil recovery rate ranged from 0.5 to 3.9 m^3/hr with an average of 2.4 m^3/hr and was not significantly affected by blower speed (Figure 15). Heavy oil caused a slight decrease in ORR; but an increase in slick thickness increased ORR as seen in Figure 16.

Two different weir skimmers were tested with the vacuum truck to determine if they would increase recovery efficiency. These were selected because of previous work; see references. These were the I.M.E. Swiss OELA III skimmer (see Figure 17) and an OHMSETT design called the Oil Spider (shown in Figure 18). Using the I.M.E. skimmer in a 25 mm slick resulted in a doubling of the RE (Figure 19) with no significant change in ORR (Figure 20). The Oil Spider performed similarly in a 12 mm slick of heavy oil.

Table 3 displays actual test results for the standard vacuum truck. One of the eleven tests resulted in low performance for both RE and ORR. In contrast, the one air conveyor test that indicated low ORR resulted in a relatively high RE (see Table 2).

TABLE 3. BEST AND WORST PERFORMANCE - VACUUM TRUCK

	RE (%)	ORR (m^3/hr)	Hose length (m)	Slick thickness (mm)	Blower speed (rpm)	Skimmer
Best performance*	40	3.5	61	25	1500	I.M.E.
Worst performance**	5	0.5	6.1	2	1200	None

*Heavy oil
**Light oil

Tables 4 and 5 list the calculated performance for both type trucks based on the fixed variables proposed in the original test matrix.

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TABLE 4. TEST RESULTS - AIR CONVEYOR

Test no.	Wave cond.	Slick thick. (mm)	Oil type (L,H)	RE (%)	ORR (m^3/hr)	Blower speed (rpm)	Hose length (m)	Hose height* (cm)
1	calm	2	L	62	0.4	1100	7.6	7.6
2	calm	12	L	52	2.8	1100	7.6	10.2
3	calm	12	L	66	2.4	1450	7.6	10.2
4	calm	12	L	50	3.1	1800	7.6	0.2
5	calm	25	L	28	6.9	1100	7.6	5.7
6	calm	25	L	77	4.2	1450	7.6	10.2
7	calm	25	L	86	4.9	1800	7.6	9.5
8	calm	25	L	85	7.8	1800	7.6	9.5
9	0.3 m HC		cancelled					
10	calm	25	H	72	5.2	1800	14.3	9.5
11	calm	12	H	54	3.2	1800	7.6	8.9
12	calm	31	H	49	4.5	1100	7.6	7.6
13	calm	25	H	50	6.1	1450	7.6	7.6
14	calm	25	H	59	5.9	1800	7.6	9.5

*Represents distance of hose end above the water surface

TABLE 5. TEST RESULTS - VACUUM TRUCK

Test no.	Wave cond.	Slick thick. (mm)	Oil type (L,H)	RE (%)	ORR (m^3/hr)	Blower speed (rpm)	Hose length (m)
15	calm	2	L	5	0.5	1200	6.1
16	calm	12	L	10	1.8	1200	6.1
17	calm	25	L	15	3.7	1200	6.1
18	calm	25	L	16	3.9	1200	61.0
19	calm	25	L	19	3.2	1200	32.0
20	calm	12	H	18	1.1	1500	6.1
21	calm	12	H	10	1.6	1500	61.0
22[1]	calm	12	H	19	1.3	2300	61.0
23[2]	calm	25	H	40	3.5	1500	61.0
24[2]	calm	25	H	30	2.6	1500	9.1
25	calm	25	H	19	2.9	1500	9.1

[1] OHMSETT Spider skimmer
[2] I.M.E. Swiss OELA III skimmer

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Figure 6. Vacuum truck in operation.

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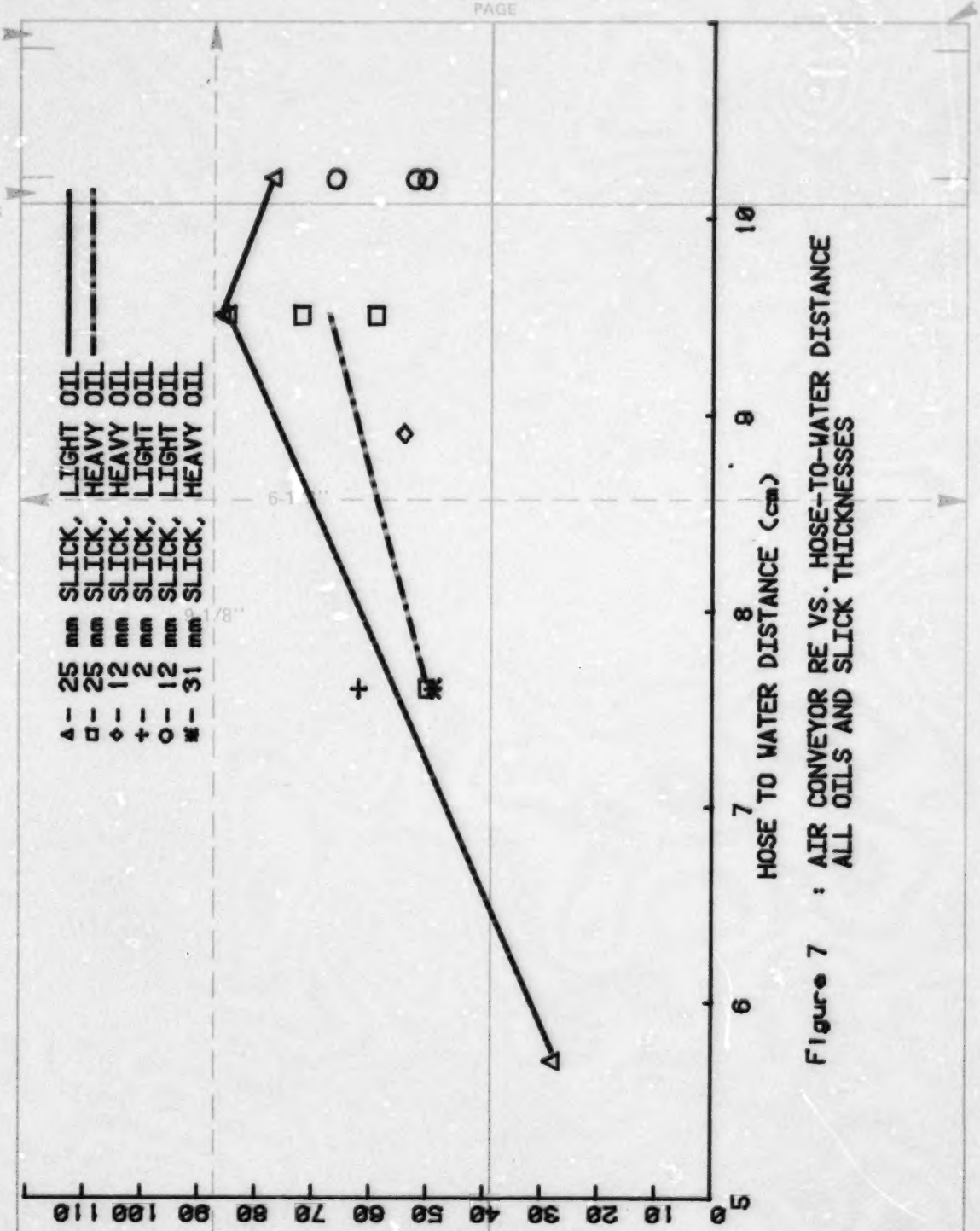

Figure 7 : AIR CONVEYOR RE VS. HOSE-TO-WATER DISTANCE ALL OILS AND SLICK THICKNESSES

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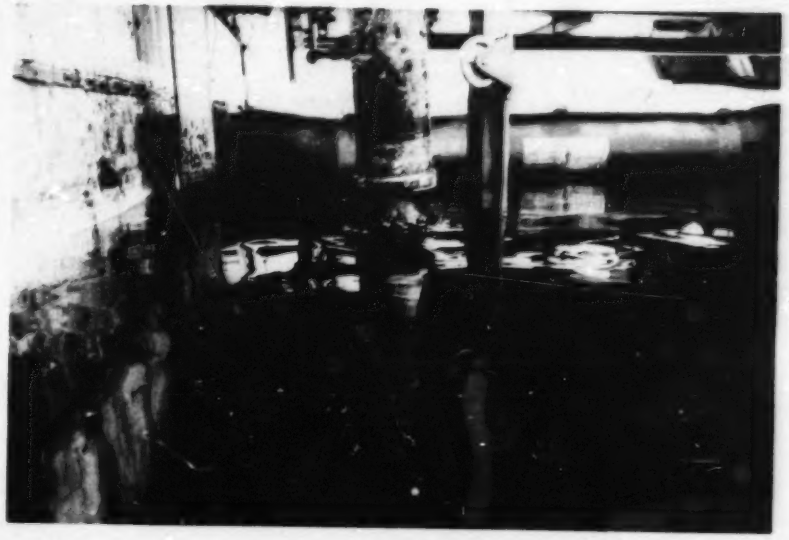

Figure 8. Hose-to-water suction cone, air conveyor.

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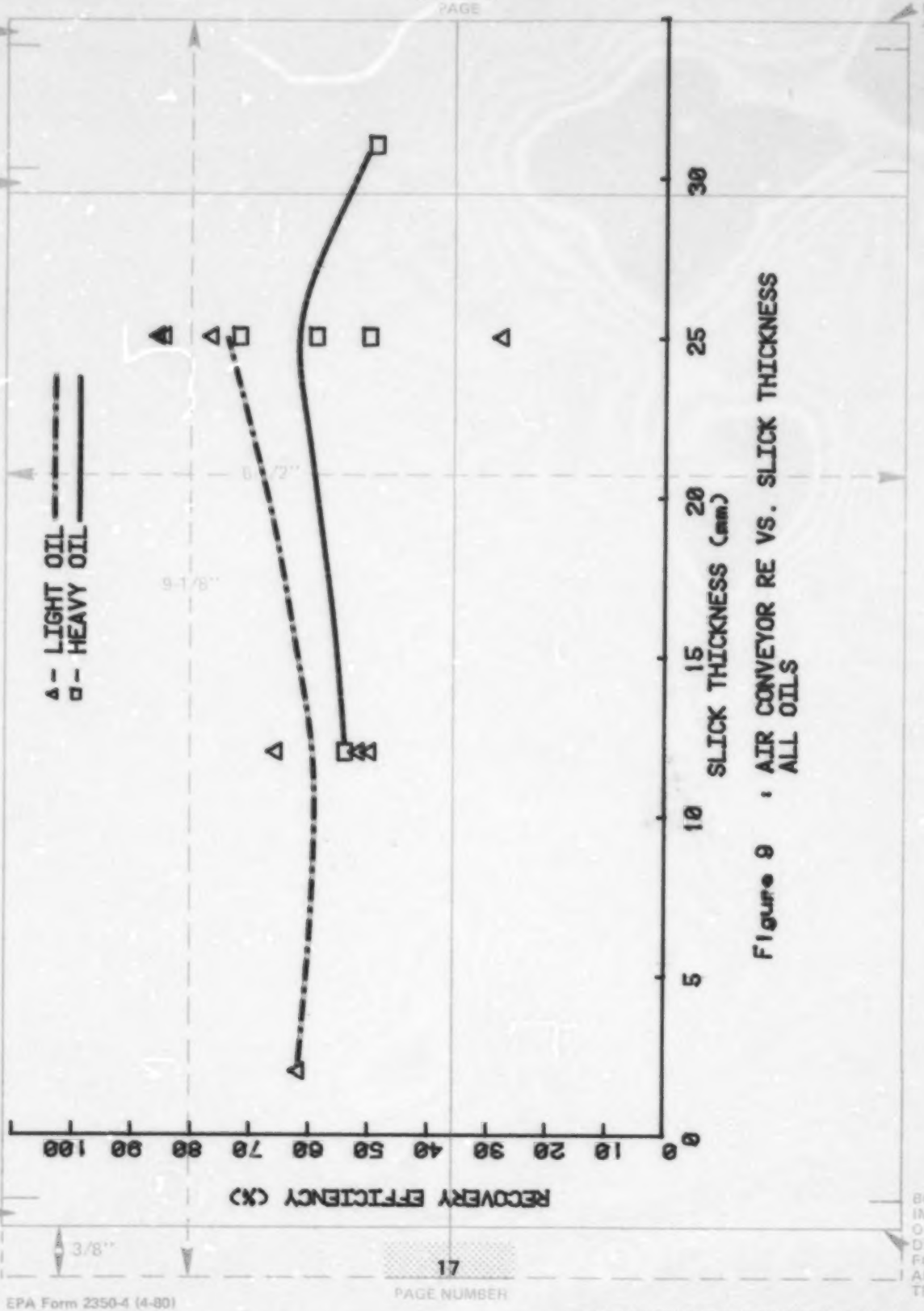

Figure 8 : AIR CONVEYOR RE VS. SLICK THICKNESS
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Figure 10 : AIR CONVEYOR ORR VS. HOSE-TO-WATER DISTANCE ALL OILS AND SLICK THICKNESSES

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Figure 11 : AIR CONVEYOR ORR VS. BLOWER SPEEDS ALL OILS AND SLICK THICKNESSES

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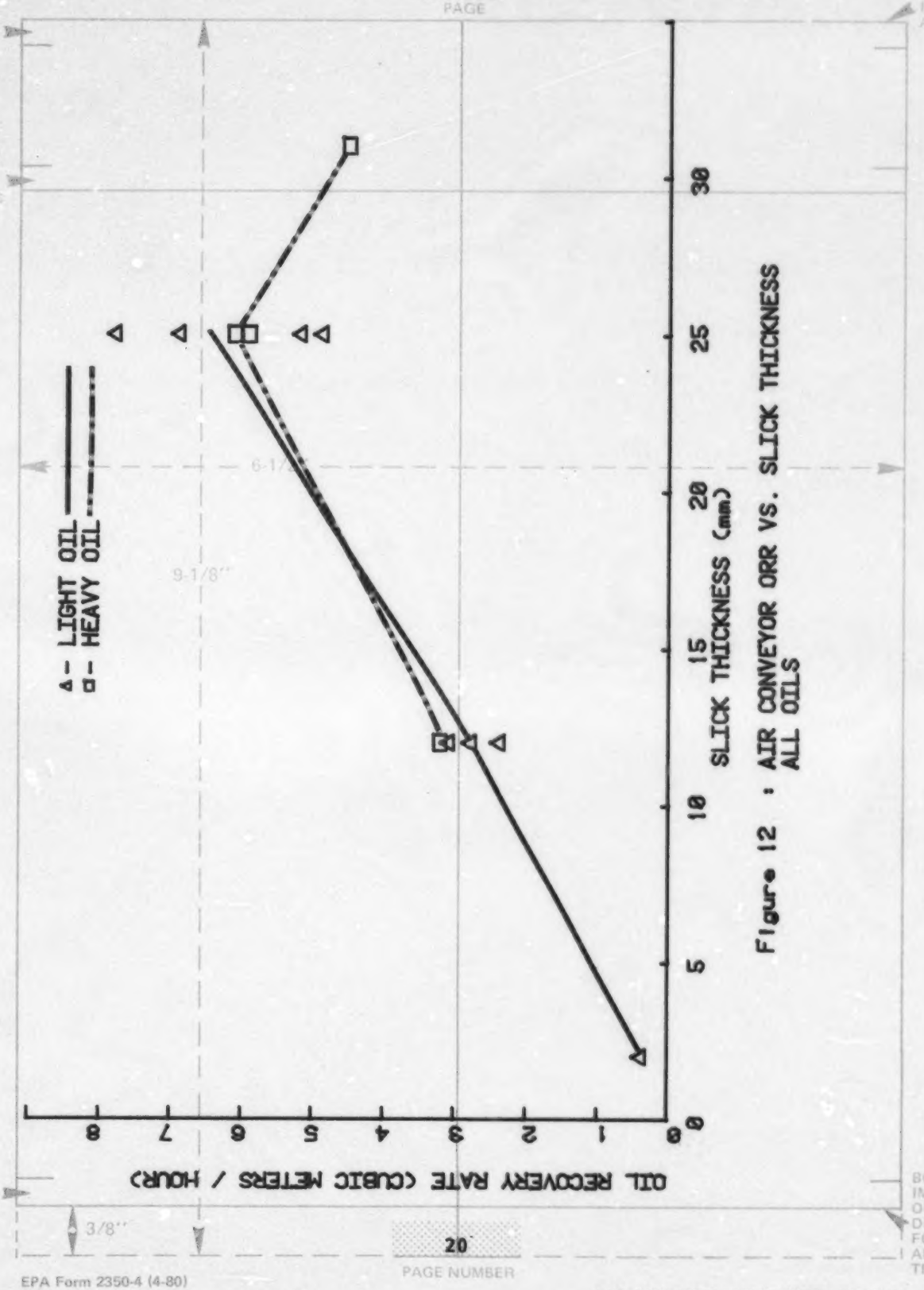

Figure 12 : AIR CONVEYOR ORR VS. SLICK THICKNESS ALL OILS

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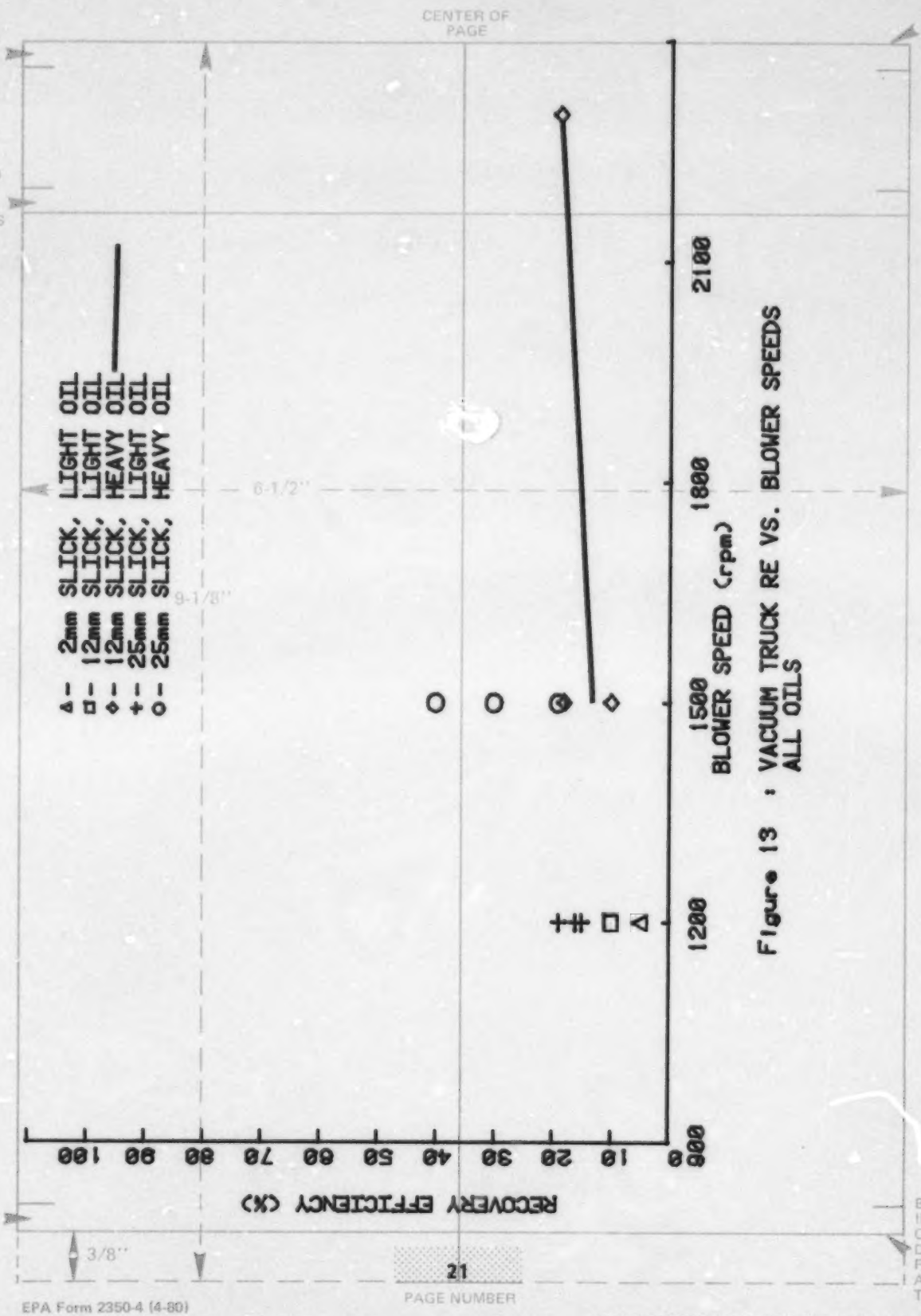
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△ -- 2mm SLICK, LIGHT OIL
□ -- 12mm SLICK, LIGHT OIL
◇ -- 12mm SLICK, HEAVY OIL
+ -- 25mm SLICK, LIGHT OIL
○ -- 25mm SLICK, HEAVY OIL
RECOVERY EFFICIENCY (%)
0 10 20 30 40 50 60 70 80 90 100
900 1200 1500 1800 2100
BLOWER SPEED (rpm)
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Figure 13 : VACUUM TRUCK RE VS. BLOWER SPEEDS ALL OILS

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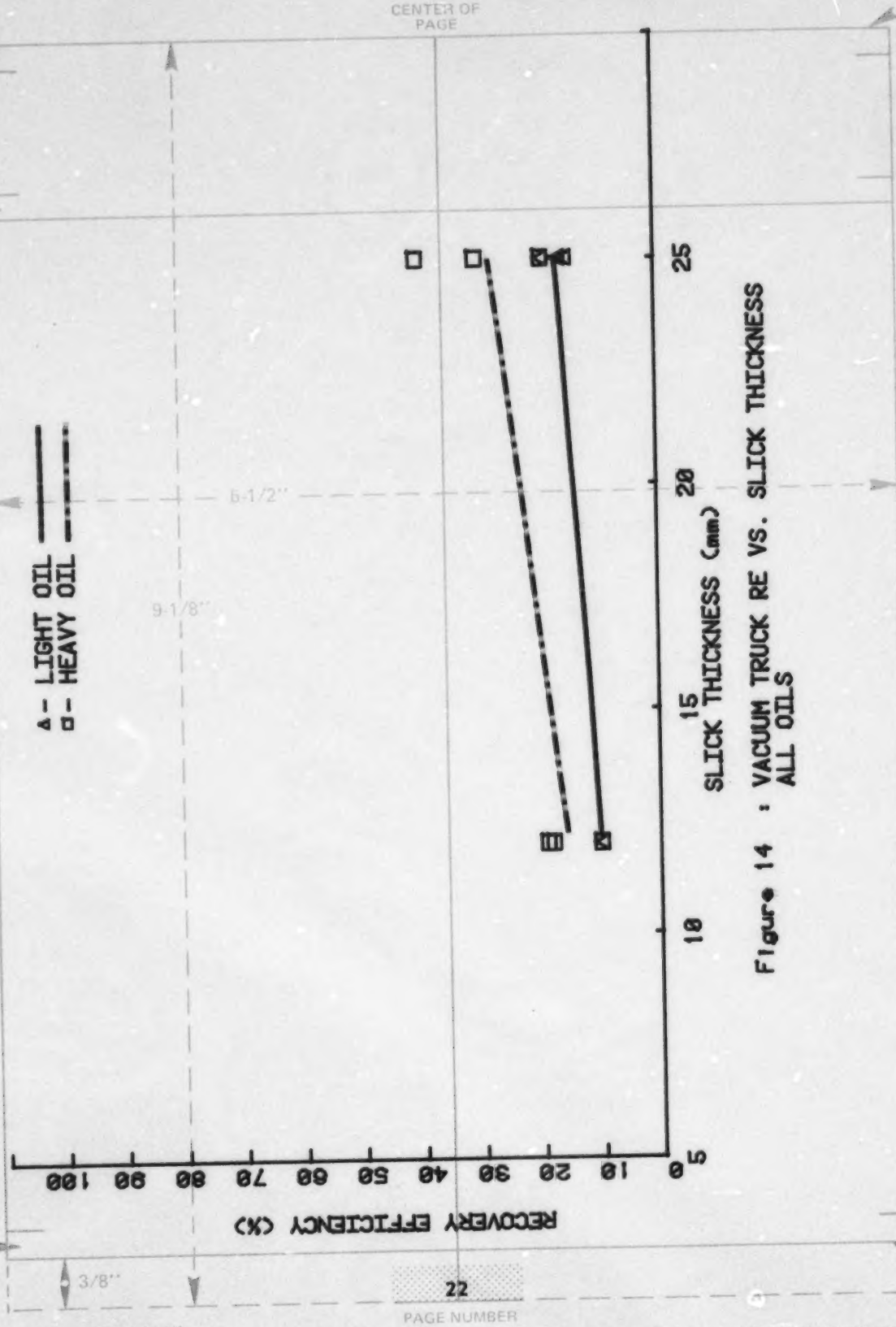

Figure 14 : VACUUM TRUCK RE VS. SLICK THICKNESS ALL OILS

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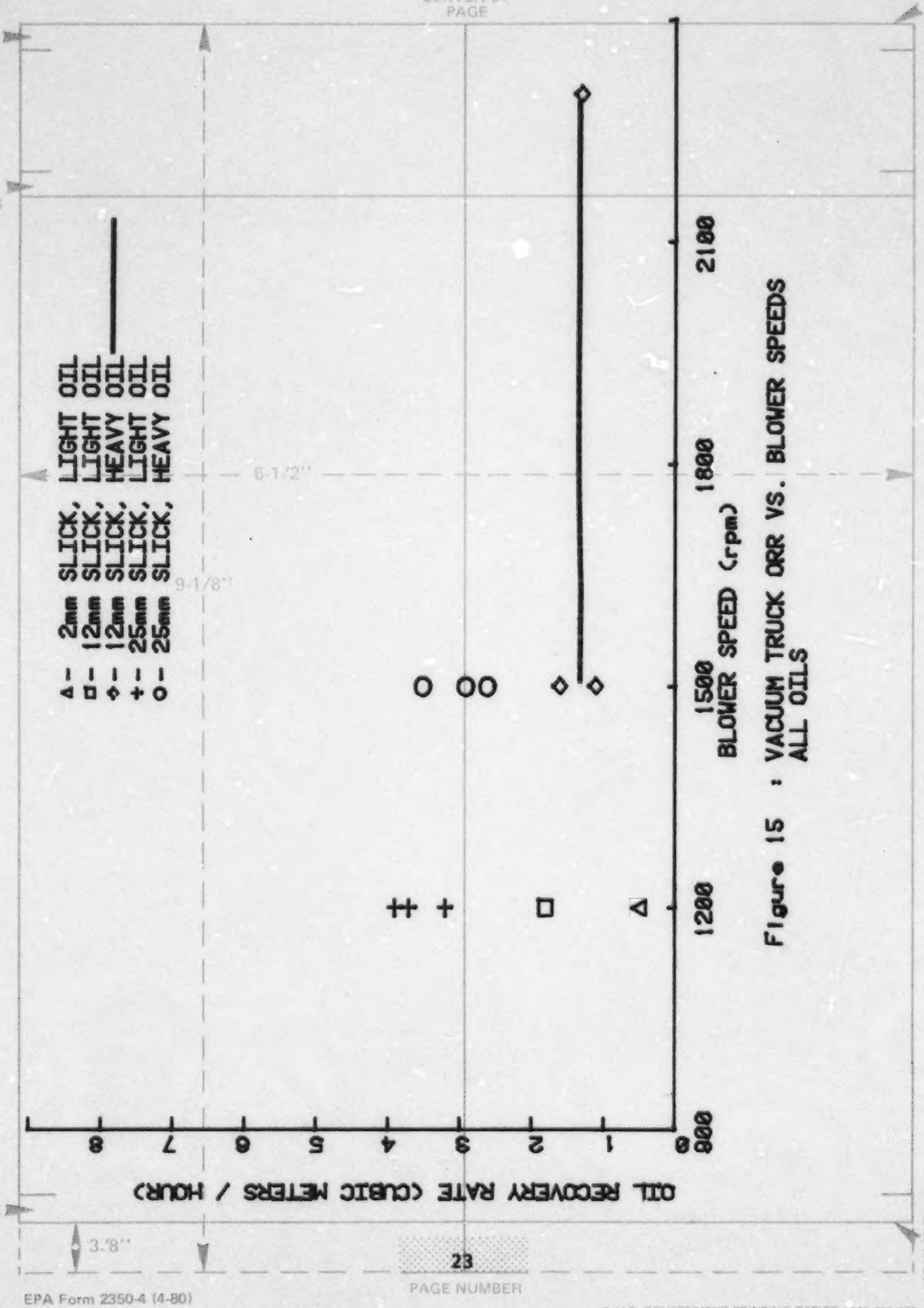

Figure 15 : VACUUM TRUCK ORR VS. BLOWER SPEEDS ALL OILS

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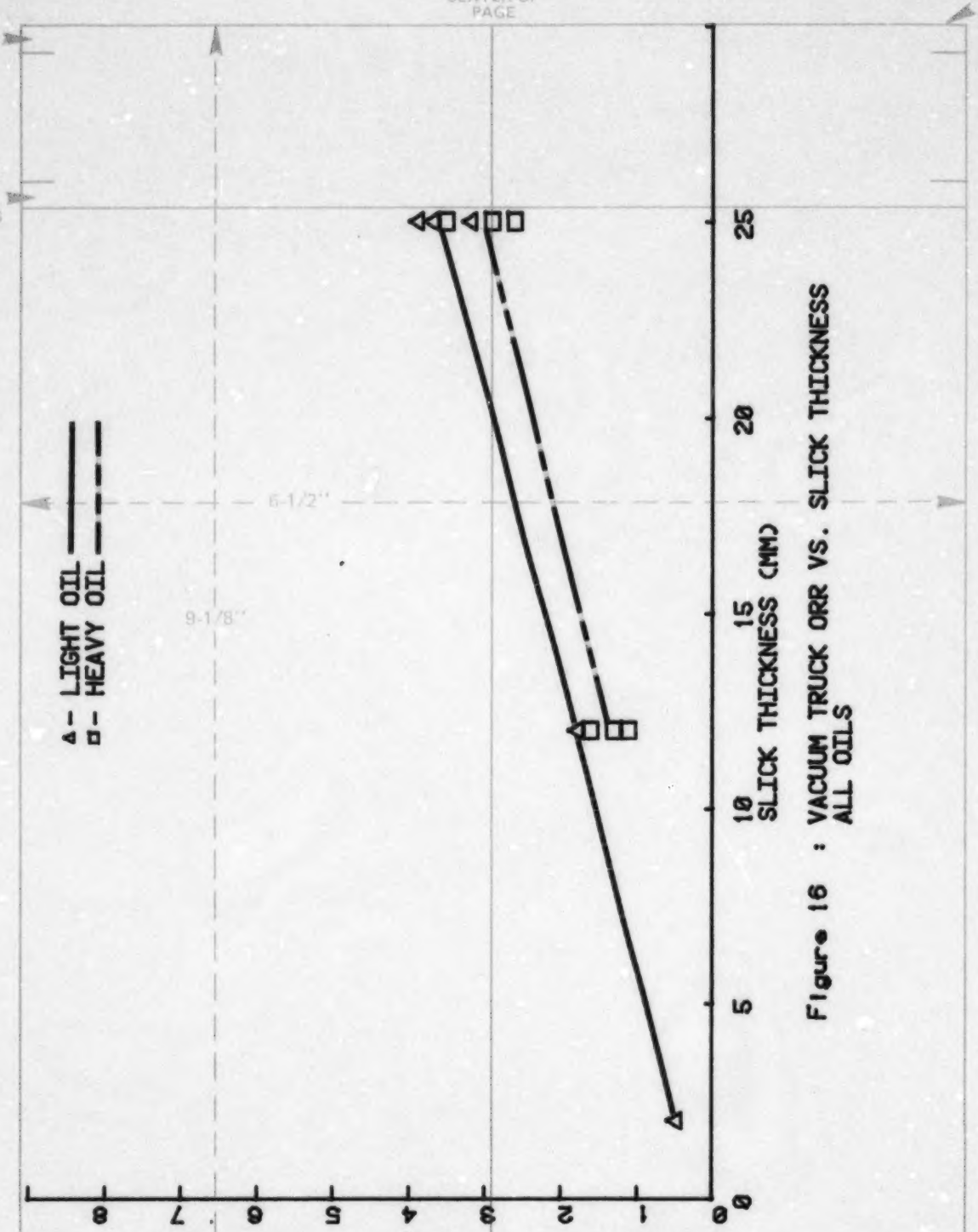

Figure 16 : VACUUM TRUCK ORR VS. SLICK THICKNESS ALL OILS

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Figure 17. IME Swiss OELA III skimming head.

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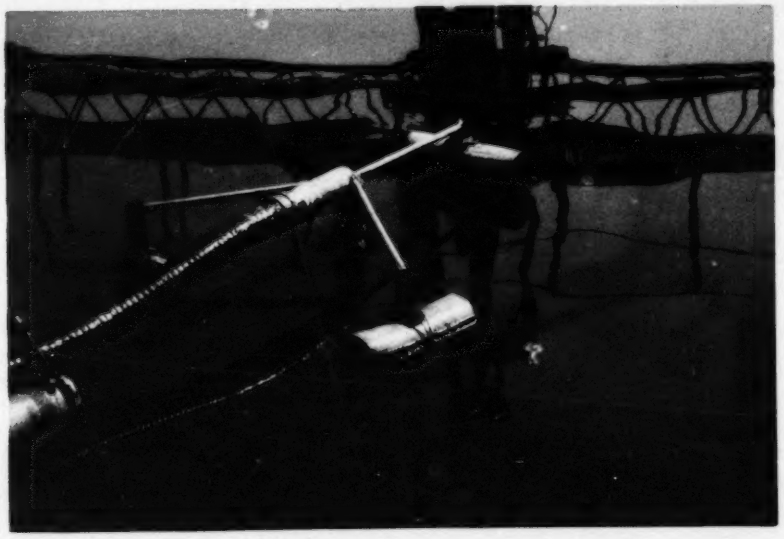

Figure 18. The Oil Spider skimming head.

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Figure 18 : VACUUM TRUCK RE VS. SLICK THICKNESS ALL OILS

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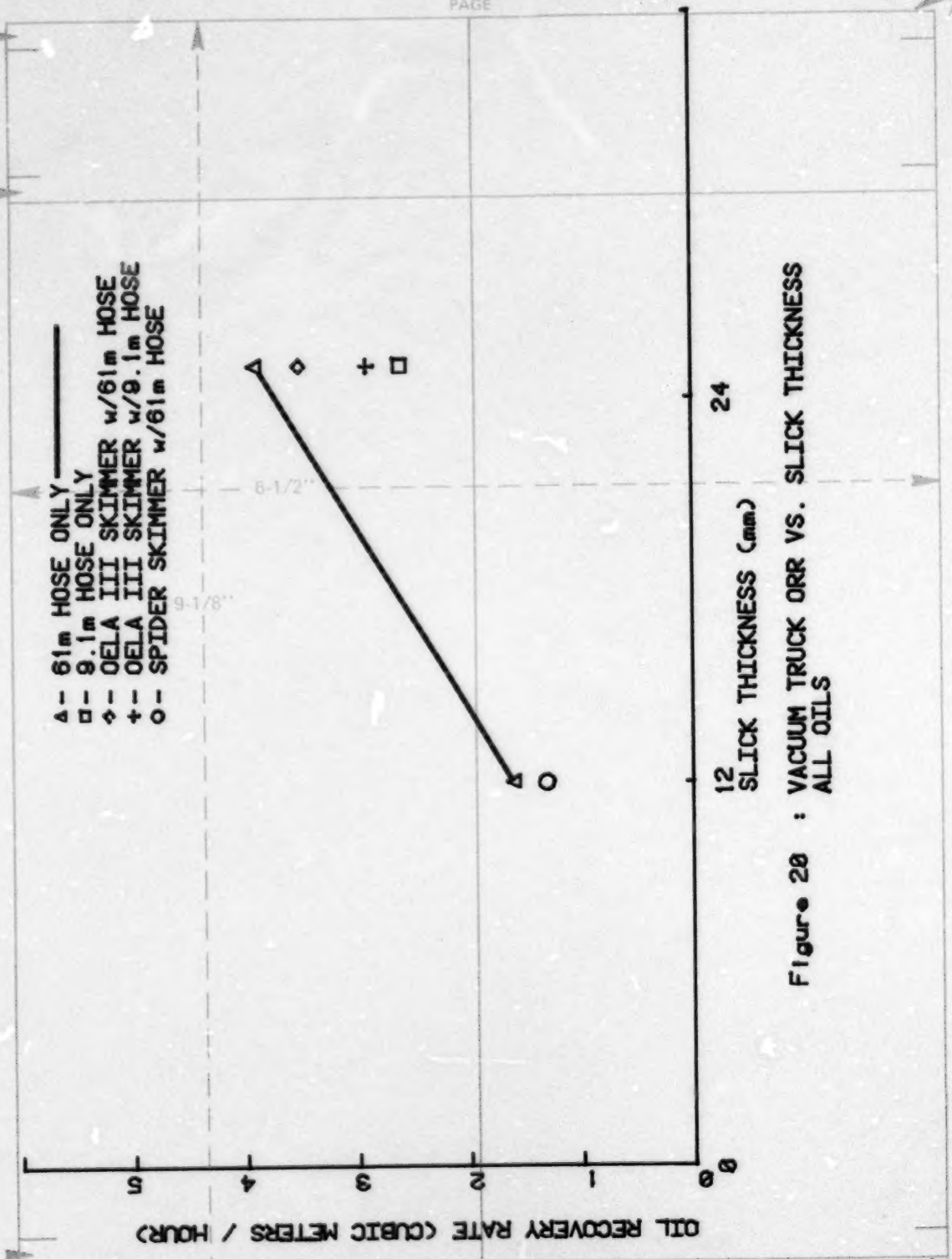

Figure 20 : VACUUM TRUCK ORR VS. SLICK THICKNESS ALL OILS

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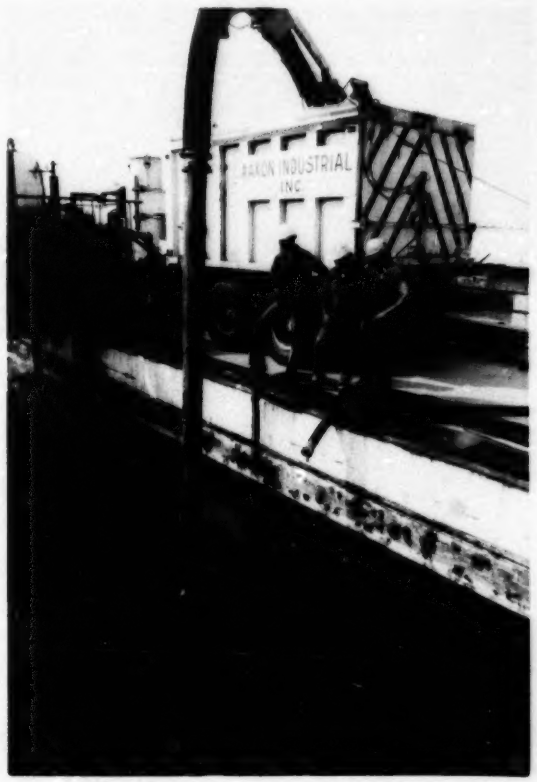

Figure 21. Air conveyor in operation.

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REFERENCES

1. McCracken, W.E. and S.H. Schwartz. Performance Testing of Spill Control Devices on Floatable Hazardous Materials. EPA-600/277-222, U.S. Environmental Protection Agency, 1977.

2. McCracken, W.E. Performance Testing of Selected Inland Oil Spill Control Equipment. EPA-600/2-77-150, U.S. Environmental Protection Agency, 1977.

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APPENDIX A

OHMSETT TEST FACILITY

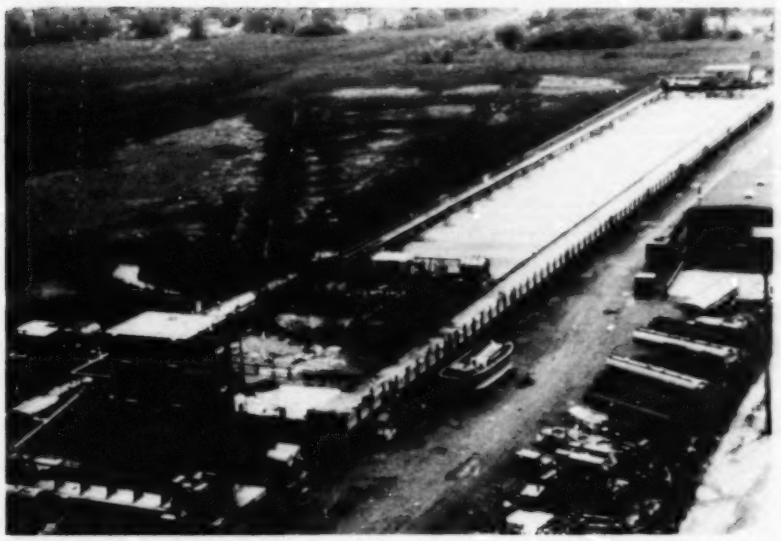

Figure A-1. OHMSETT Test Facility

GENERAL

The U.S. Environmental Protection Agency operates the Oil and Hazardous Materials Simulated Environmental Test Tank (OHMSETT) located in Leonardo, New Jersey (Figure A-1). This facility provides an environmentally safe place to conduct testing and development of devices and techniques for the control of oil and hazardous material spills.

The primary feature of the facility is a pile-supported, concrete tank with a water surface 203 meters long by 20 meters wide and with a water depth of 2.4 meters. The tank can be filled with fresh or salt water. The tank is spanned by a

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bridge capable of exerting a force up to 131 kilonewtons, towing floating equipment at speeds to 3 meters/second for at least 45 seconds. Slower speeds yield longer test runs. The towing bridge is equipped to lay oil or hazardous materials on the surface of the water several meters ahead of the device being tested, so that reproducible thicknesses and widths of the test fluids can be achieved with minimum interference by wind.

The principal systems of the tank include a wave generator and beach and a filter system. The wave generator and absorber beach have capabilities of producing regular waves to 0.7 meter high and to 28.0 meters long, as well as a series of 1.2 meter high reflecting, complex waves meant to simulate the water surface of a harbor or the sea. The tank water is clarified by recirculation through a 468 cubic meter/hour diatomaceous earth filter system to permit full use of a sophisticated underwater photography and video imagery system and to remove the hydrocarbons that enter the tank water as a result of testing. The towing bridge has a built-in skimming barrier which can move oil into the north end of the tank for cleanup and recycling.

When the tank must be emptied for maintenance purposes, the entire water volume of 9842 cubic meters is filtered and treated until it meets all applicable state and federal water quality standards before being discharged. Additional specialized treatment may be used whenever hazardous materials are used for tests. One such device is a trailer-mounted carbon treatment unit for removing organic materials from the water.

Testing at the facility is served from a 650 square-meter building adjacent to the tank. This building houses offices, a quality control laboratory (which is very important since test fluids and tank water are both recycled), a small machine shop, and an equipment preparation area.

This government-owned, contractor-operated facility is available for testing purposes on a cost-reimbursable basis. The operating contractor, Mason & Hanger-Silas Mason Co., Inc., provides a permanent staff of 21 multi-disciplinary personnel. The U.S. Environmental Protection Agency provides expertise in the area of spill control technology, and overall project direction.

For additional information, contact: Richard A. Griffiths, OHMSETT Project Officer, U.S. Environmental Protection Agency, Research and Development, MERL, Edison, New Jersey 08837, 201-321-6629.

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APPENDIX B

PROPERTIES OF OHMSETT TEST OILS AND TANK WATER

Oil

The test oil was sampled and analyzed daily. Surface tension and interfacial tension with tank water were measured at room temperature using a Fisher Scientific Model 21 Surface Tensiomat. The viscosity was measured using a Brookfield Model LVT viscometer at room temperature and a Fisher/Tag Saybolt viscometer at an elevated temperature. Viscometer results were converted to centistokes using ASTM D2161-74 and plotted using ASTM D341 viscosity temperature charts for interpolation at ambient conditions. A summary of the physical properties of the test oils is given below.

TABLE B-1. TEST OIL PROPERTIES

Oil type	Specific gravity	Viscosity cSt, 23°C	Viscosity cSt, 73°C	SFT dynes/cm	IFT dynes/cm	% water & sediment
Circo X heavy	.930	941.0	50.6	49.9	16.6	0.2
Circo light	.892	16.0	8.3	35.4	19.2	0.1

SFT=surface tension
IFT=interfacial tension

Water

The tank water was analyzed for temperature, specific gravity, salinity, conductivity, pH, turbidity, and suspended solids. These tests were performed in accordance with the guidelines published in ASTM Standards, Part 31, Water, and ASTM Standards, Part 23, Petroleum Products and Lubricants (1). The temperature is measured with a Markson Science, Inc. Model 5650 Digital Thermometer following the Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, and WPCF; 13th Edition, 1971. The specific gravity is determined with hydrometers as specified by ASTM D-1298-67. Salinity and conductivity measurements are performed on the YSI Model 33 SCT meter. The pH measurements are taken with a Fisher Scientific Company Model 120 pH meter as described in ASTM D1293-65. Turbidity is obtained with a Hach Chemical Company Model 2100 Turbidimeter following ASTM D1889-71. Suspended solids are measured gravimetrically as outlined in Methods for Chemical Analysis of Water and Wastes, p. 266, EPA-625-16-74-003, 1974, U.S. EPA. Typical water quality measurements are shown in Table B-2.

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TABLE B-2. PHYSICAL PROPERTIES OF TANK WATER

ph	7.4
Specific gravity	1.014
Temperature (°C)	20.7
Salinity (ppt)	17.5
Conductivity (umhos)	26,000
Suspended solids (mg/l)	31.0

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